

# Improved Navy Lighterage System (INLS) Throughput Analysis Update

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# **Improved Navy Lighterage System (INLS) Throughput Analysis Update**

**Robert R. Adams**

**March 2002**

The INLS is a research and development program to design a more capable ship-to-shore lighter system. Because there has not been an analysis to fully assess the system's throughput in supporting the offload of a Maritime Prepositioning Force (MPF) squadron, this report assesses INLS offload capabilities using the latest system parameters.

Analysis was begun with expected parameters of the INLS components constructed of both steel and composite materials. After preliminary results were reported to the sponsor and program manager, revised INLS component weights for the final steel system designs were provided. This annotated briefing documents values for the MPF squadron.

## Task objectives

- Using new component parameters, validate times to offload and assemble a squadron set of INLS lighterage to support an MPF offload
- Determine the lighterage requirement to match the capabilities of current NL systems
- Examine the impact of an RRDF on MPF offload efficiency, using the RRDF as an asset for vehicle offload, and using the components of the RRDF to make longer ferries.

This slide spells out the specific objectives of our analysis. We identify the throughput capabilities of today's naval lighterage (NL), and identify INLS assets to match the current offload rate for an MPF squadron. Several excursions to this base case analysis are then conducted to show the effects of:

- Reconfiguring the base case's modules/sections into different ferry sizes with their roles tailored to optimize offload efficiency
- Varying the number of operational ferries in the squadron
- Doubling the range of MPF ships from the beach
- Examining the impact of a roll-on/roll-off discharge facility (RRDF) on the squadron offload.

## Outline

- Background
- MPF throughput analysis
- Variations in INLS designs and throughput
- RRDF considerations
- Summary

This annotated briefing will cover the areas shown above.

## Background

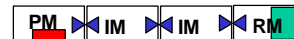
- CNA provided analytical support to N42 during the ACTD for JMLS
- CNA analysis supported decision to stop ACTD
- CNA analysis modeled time to assemble lighterage and offload MPF shipping to calculate required lighters to match current systems' throughput
- The INLS program incorporates the lessons learned from the JMLS ACTD and earlier analyses, so N42 has asked CNA to reevaluate the assembly and throughput analysis using revised INLS parameters

Here we summarize the background of the analysis. This work extends analytical support to N42 provided during the Advanced Concept Technology Demonstration (ACTD) for the Joint Modular Lighterage Systems (JMLS) and several follow-up analyses [1-3]. Those analyses showed that the Navy's lighterage requirement could be better met with larger components that are not compatible with the international standards organization (ISO) container size constraints.

Findings of this analysis apply to the larger components of the new INLS acquisition program. Results presented show the MPF squadron set required for INLS to match the throughput capabilities of the current lighters with the latest INLS system parameters.

# INLS Ferry Design

- **Baseline:**
  - 3 section ferry
  - single power section
- **Alternatives:**
  - 4 section ferry
  - 2 section ferry
  - RRDF components



- Flex connector	PM - Power module	RM - Ramp module
- Rigid connector	CMM - Causeway male	CMF- Causeway female
	IM - Intermediate module	

The INLS system includes ferries, warping tugs, Roll-on/roll-off discharge facilities (RRDF), and floating causeways. This page describes the different ferry designs that we examined in our analysis.

The baseline INLS ferry is made up of three sections, each 24 feet wide and 80 feet long. A power module contains the ferry prime mover and a pilot house and shelter for the ferry crew. The power module is connected by a flexible connector to an intermediate module, which is connected to a beach ramp module, again by a flexible connector.

The number of modules in a ferry can be varied, and we looked at three variations in ferry length:

- A 4-section ferry, with an extra intermediate module included
- A 2-section ferry, composed of only a power and beach ramp module
- A 4-section ferry, with two causeway modules replacing the intermediate module. The two causeway modules would come from the RRDF, and are rigidly connected.

The program manager estimates that each ferry option would have a speed of about 10 knots, and provided weights and load capacities for each module type.

## INLS module summary

Module	Weight (LT)	Capacity (LT)
Intermediate module	81.7	125.9
Combination module female	87.1	120.5
Combination module male	80.8	126.8
Beach Ramp module	82.6	92.4
Power module	120.5	62.0

The table displays the individual module weight and load capacity provided by the program office for the final INLS components.

The power module weight is too large for a twin lift by the cranes on any MPF ship, or an auxiliary crane ship (TACS).

Using four cranes from multiple pedestals will slow the offload and assembly time for the ferries.

## Analysis assumptions

- INLS ferries carry single cargo type
- Cargo on MPF ship is spread loaded; therefore, cargo types are offloaded concurrently
- Ferry square loading factor for vehicles is 65 percent
- Ship offloading cycle is 20 hrs in a 24-hr period
- Two, three, and four-section ferries are options
- Operating factors for cargo handling are same as the ones for earlier CNA studies on naval lighterage
- MPF ship standoff range from beach is 3 n.mi.

Key assumptions governing the analysis are shown on this slide.

We assume that a given ferry does not mix its cargo. Mixing cargo types, e.g., vehicles and containers, would complicate offloading at the beach and require additional rough terrain container handlers (RTCHs).

MPF ships do mix their cargo types. Thus, vehicles, containers, and tanks are offloaded simultaneously. A mixed cargo stream is essential to satisfying user demand on the beach.

Vehicle placement on ferries is 65 percent efficient in using the available space.

Ship offloading operations stand-down 4 hours each day. This 4-hour break allows for both ship equipment maintenance and repair, and lighterage upkeep.

To improve overall offload efficiency, we configure ferries with 2, 3, and 4 sections in some analysis excursions. Because the longer ferries are hydrodynamically more efficient than the 2-section ferry, they require less power per ton for propulsion. We therefore assume that all ferries can sustain the program office provided transit speeds of 10 knots.

Operating factors, including ship offloading times per unit, cargo types, ferry mooring/beaching cast off times, and offloading ferry times are identical to those cited in earlier CNA studies [3].

MPF ship standoff range in the base case analysis is 3 n.mi.

## INLS analysis findings

### **MPF squadron offload using ferries:**

- Our base case, using final steel INLS values:
  - has 15 3-section ferries and 5 warping tugs per squadron;
  - offloads a 5-ship MPF squadron in about 8.3 days
  - weighs 4922 LT (1049 LT more than today's NL lighters)
- If ships in the base case use their 15 3-section ferries to design 4-, 3-, and 2-section ferries they can shorten the offload time by almost a day
- Compared to steel, ferries made of composites would reduce squadron lighterage weight by about 1,000 LT
- A 6-n.mi. ship standoff range adds 10 hrs to ship offload time

Our base case INLS for a 5-ship MPF squadron using fifteen 3-section ferries completes its offload operation in slightly less than 8.3 days. This is comparable to current NL capabilities with 16 NL ferries. However, INLS capabilities permit 10-knot versus 4-knot speeds, and sea state 3 versus sea state 2 operations, making the INLS a more robust force option. INLS ferries weigh about 27 percent (1049 LT) more than a comparable squadron set of NL lighters.

INLS ferries made of composites would be roughly 20 percent lighter than their steel counterparts. They could carry slightly heavier loads; thus, they would have a slight advantage in offload time. The steel INLS in our base case for a MPF squadron weighs 4922 LT. Today's NL system weighs 3873 LT..

Reconfiguring the modules available in the base case to construct equal numbers of 4-, 3-, and 2-section ferries can reduce offload times by almost a day.

If ships experience a catastrophic failure with one power section, a good fallback position is to work with a 4-section and a 3-section ferry. Offload times compared to the base case increase by 1 day.

Doubling the ship's standoff range to 6 n.mi. increases the offload time by less than a half day. This is another advantage of the higher speed available in the INLS design.

## **Recommendations**

- To both enhance operational capabilities and avoid major increases in the weight of current lighterage, we recommend consideration of 15 INLS ferries (with 3 sections each) for an MPF squadron
- To achieve weights similar to today's NL, composites must be used for the construction of ferries and warping tugs

We recommend the assets for our base case (15 INLS 3-section ferries and 5 warping tugs) for an MPF squadron of five ships. If these lighterage components are made from composites, their overall weight would be close to today's NL. Steel-construction components would meet lighterage requirements, but would add another 1,049 LT to the squadron's cargo.

## Analysis outline

- Nominal MPF ship's cargo load
- Ferry load sizes for various cargo types
- Ferry operating cycles (time at ship + time at beach + 2-way transit time)
- Numbers of ferry loads of vehicles, containers, and tanks on a ship; times needed by single ferries of various sizes to offload a ship
- Base case and four excursions including:
  - Optimization of base case's performance
  - Doubling base case ferry range to 6 n.mi.
  - Losing one of a ship's ferry power sections
  - Reducing the number of ferries from 15 to 12
  - Building a squadron RRDF, offsetting its weight by having fewer ferry intermediate modules

Here we provide an outline of the analysis that this paper covers. Its findings provide the basis for the conclusions and recommendations presented earlier.

We first examine the cargo loadout of a nominal MPF ship. We then determine ferry load sizes for vehicles, containers, and tanks, allowing for various ferry configurations.

We next determine ferry operating time cycles by considering the times spent alongside the MPF ship, transiting, and carrying out beach-offloading operations. This information, in conjunction with ferry loads, is needed to determine ship offload times.

We conclude with the analysis of our base case and the five excursions listed on the slide.

## Nominal single MPF ship's cargo

Cargo type	# of items	avg sqft	avg weight (LT)
vehicles	637	175	7.6
tanks	13	425	62.5
containers	560	8' x 8' x 20'	13.0

This slide provides information on the loadout of a nominal MPF ship. It lists the numbers of vehicles, tanks, and containers, and gives their average footprints and weights. We use this information to estimate the load sizes of the various ferry sizes we consider. In our baseline squadron offload model, each ship essentially acts independently.

## Characteristics of ferries

lighterage	size	weight (LT)	load limit (LT)
INLS (3-sect: steel)	24' x 250'	284.8	280.3
INLS (3-sect; composite)	24' x 250'	242.2	335.0
INLS (4-sect with CM; steel)	24' x 330'	371.0	401.7
INLS (4-sect with IM; steel)	24' x 330'	366.5	406.2
INLS (2 sect; steel)	24' x 170'	203.1	15.4
NL (3-sect; today's)	21' x 270'	218	160.7

This chart describes the ferry designs we consider in our analysis. It provides information for the five candidate INLS designs and today's lighterage. Note that the INLS (composite) 3-section ferry can carry a 20-percent heavier load than the one built from steel. However, vehicle, container and tank loads turn out to be the same for both INLS construction materials. A single ferry mid-section is limited to two tanks. (Vehicle and container loads are governed by space, not weight.)

Note also the table includes information for INLS ferries (steel) consisting of four and two sections. A four section INLS ferry could have a two-section wide unit constructed from either two intermediate modules (IM) or two combination modules (CM) taken from RRDF components. Both these four-section have comparable load limits.

Today's NL (steel) ferry weights 76 percent as much as an INLS (steel) ferry and can carry 58 percent of its weight load.

## Load sizes for INLS ferries

Ferry size/type	# vehicles	# tanks	# containers
3-section/steel	15	4	16
3-section/composite	15	4	16
4-section/steel	22	6	25
4-section/composite	22	6	25
2-section/steel	8	2	7

A 2-section ferry has only a power section and a beach-end section. Three-section ferries have a middle section; four-section ferries have two middle sections. Space available on a given ferry depends on the number and type of sections used to assemble the ferry. A beach end section has a useable 40' x 24' deck area; a power section has a 50' x 24' area; and a middle section has an 80' x 24' area.

Load sizes for the three ferry sizes (3, 2, and 4 sections) are listed here. Cargo types are vehicles, tanks, and containers. Use of composites does not affect the individual ferry loads.

## INLS ferry operating times (hr)

ferry type	at ship	at beach	2 x transit	cycle time
3-section				
vehicles	3.85	.75	.60	5.20
cont.	1.95	1.58	.60	4.13
2-section				
vehicles	2.22	.52	.60	3.34
cont.	1.05	.83	.60	2.48
4-section				
vehicles	5.48	.98	.60	7.06
cont.	2.85	2.33	.60	5.78

This slide breaks a ferry's operating cycle into its three time components: the time spent near the MPF ship, the time spent at/near the beach, and the time used to travel back and forth between the ship and beach.

A ship can offload at most to two ferries at the same time, one on its port side and one on its starboard side. The near-ship time for a given ferry is the sum of the ferry approach/moor time (15 minutes), the offload time, and the ferry's cast-off time (6 minutes). Cargo offload time depends on cargo type. Tank and vehicle crane lifts require an average of 14 minutes each. Containers require 6 minutes each.

At the beach the ferry must stab the beach (6 minutes), unload its cargo, and clear the beach (10 minutes). Unloading times are 2 minutes for a vehicle and 3 minutes for a tank. Ferries carrying containers take 5 minutes to offload a container.

For an MPF ship anchored 3 miles out, the two-way transit time at 10 knots is 36 minutes or 0.6 hour.

Operating cycles for ferries with 2, 3, and 4 sections are shown in the last column of the table. Two-section ferries have the shortest cycles, a little over 3 hours, and the 4-section ferries have the longest, about 7 hours. These operating cycles are important. Along with the number of loads of each type of cargo (containers, vehicles, and tanks) carried by an MPF ship, the length of the operating cycle governs the amount of time it takes a given lighter force to offload a squadron of MPF ships.

## Vehicle offload time for 1 INLS ferry

INLS ferry type	# loads	cycle time (hr)	offload (days)
3-section	42.5	5.20	11.04
2-section	79.6	3.34	13.30
4-section	29.0	7.06	10.22

This slide looks specifically at vehicles carried by the three sizes of ferries we described. In the second column it shows the total number of ferry loads carried by the MPF ship. For the longest ferry it is 29; for the two-section ferries it is essentially 80, more than double.

The third column shows the cycle times listed in the previous slide. The final column shows the total time it would take one ferry to offload the vehicles of an MPF ship. We assume that the ferry would operate 20 hours per day, as noted earlier in our assumptions.

Noteworthy is the fact that the offload times for the 3- and 4-section ferries differ by only 0.8 day. Also, both require more than 10 days and today's lighterage can offload in only 8.5 days. More ferry lift is obviously suggested for vehicles.

It should be noted (also applies to next two slides) that these times do not include the time for ferry and warping tug assembly. They will be accounted for later.

## Container offload time for 1 INLS ferry

INLS ferry type	# loads	cycle time (hr)	offload days
3-section	35	4.13	7.22
2-section (steel)	80	2.48	9.92
4-section	22.4	5.78	6.47

The numbers of loads needed to offload containers with a single steel ferry are comparable to those for offloading vehicles. However, the cycle times are only about 75 percent of those for vehicles, resulting in offload times roughly 3.5 days shorter. Therefore, single 3- and 4-section ferries can unload an MPF ship's containers in 7.2 and 6.5 days, respectively.

## **Tank offload time for 1 INLS ferry**

INLS ferry type	# loads	cycle time (hr)	offload (days)
3-section	3.3	2.35	.39
2-section	6.5	1.77	.58
4-section	2.2	2.92	.32

The above slide provides the same information for tanks that was just provided for vehicles and containers. The small number of loads required to carry 13 tanks and the relatively short cycles result in single ferry times between 0.32 and 0.58 days.

## INLS analysis cases for MPF squadron

Case	# Ferries/sections & assignments	Lighterage wt(LT)	Time (days)
Base	15/50 10 RO/RO, 5 containers (all ferries have 3 sections)	4,922 (steel) 4,122 (composite)	8.3
Base optimized	15/50 5 RO/RO, 5 containers, 5 alternate (ferries have 4, 3, and 2 sections)	4,922 (steel) 4,122 (composite)	7.5
Base (6 n.mi. range)	15/50 same as base case	4,922 (steel) 4,122 (composite)	8.7
Base, loss of 1 power section (and a ramp) per ship	10/40 5 RO/RO, 5 containers (ferries have 4 and 3 sections)	3,906 (steel) 3,300 (composite)	9.3
12 ferries	12/44 5 4-sections, 5 3-section and 2 2-section ferries	4,313 (steel)	9.1
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> Today's NL is 3,873 LT </div>			

To explore the potential capabilities of our base case (three 3-section ferries) per MPF ship, or 15 ferries for a 5-ship MPF squadron, we considered the four excursion cases listed on this slide. Note that the number of sections in the second column of the slide includes five warping tugs.

The base case dedicates two of its 3-section ferries per MPF ship to vehicles and one to containers and tanks. The base “optimized” case reconfigures the base case ferries differently: it dedicates a 4-section ferry to vehicles and a 3-section ferry to containers, and has a 2-section ferry alternate between vehicles and containers. This strategy sustains near-continuous offloading of vehicles and augments the container/tank offload.

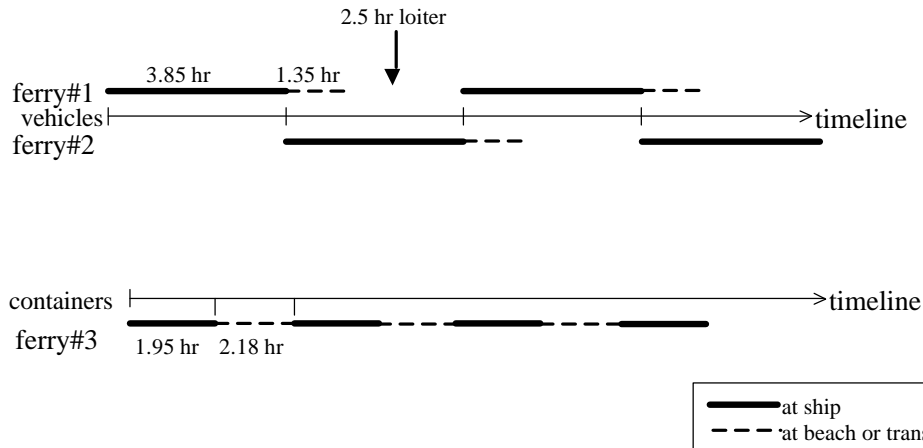
The base (6-n.mi. range) excursion shows the impact of increasing the ship’s standoff range to 6 n.mi. from 3 n.mi.

The third excursion examines the impact of ships each losing the use of a ferry power section. The fallback position is to operate one 4-section ferry and one 3-section ferry.

The next excursion, done at the sponsors request, considers 12 ferries for the squadron. Two ships have three ferries (4-, 3-, and 2-sections, respectively; three ships have two ferries (a 4-section and a 3-section).

Noteworthy in the table is that the lighterage weight for the squadron is the same for the first four cases. For the 12-ferry excursion, the lighterage weight drops by 12 percent to 4,313 LT. The capabilities of the INLS are much greater than those of today’s lighterage.

## Three-section ferry ops (base case)



For our base case we chose a scenario where two ferries offload vehicles from one side of the ship and a single ferry offloads containers and tanks from the other side. This slide depicts that operation.

The three slides for cargo offload capabilities (shown earlier) suggest that at least three ferries would be needed to offload an MPF ship in 8.5 days. A single 3-section ferry (made of either steel or composites) needs 11.04 days and 42.5 loads to unload the ship's vehicles. It spends 3.85 hours (74 percent of its 5.2-hour cycle) at the ship. The remaining 26 percent of time (1.35 hours of the 5.2-hour cycle) is spent in transit and at the beach. This means that adding a second ferry for vehicles would easily sustain a continuous vehicle offload operation (20 hours in 24 hours), but at the cost of having one of these ferries idle 2.5 hours in a 7.7-hour cycle. This enables the ship's vehicles to be offloaded in 8.18 days. This is calculated by multiplying the number of vehicle loads by the time a ferry spends near the ship and dividing by 20 hours.

A single 3-section ferry (steel) can offload the ship's containers in 7.22 days, spending 1.95 hours of its 4.13-hour cycle (47 percent of the time) at the ship. Adding 0.39 day for tanks to this ferry's workload would raise this time to 7.61 days.

## **Base case**

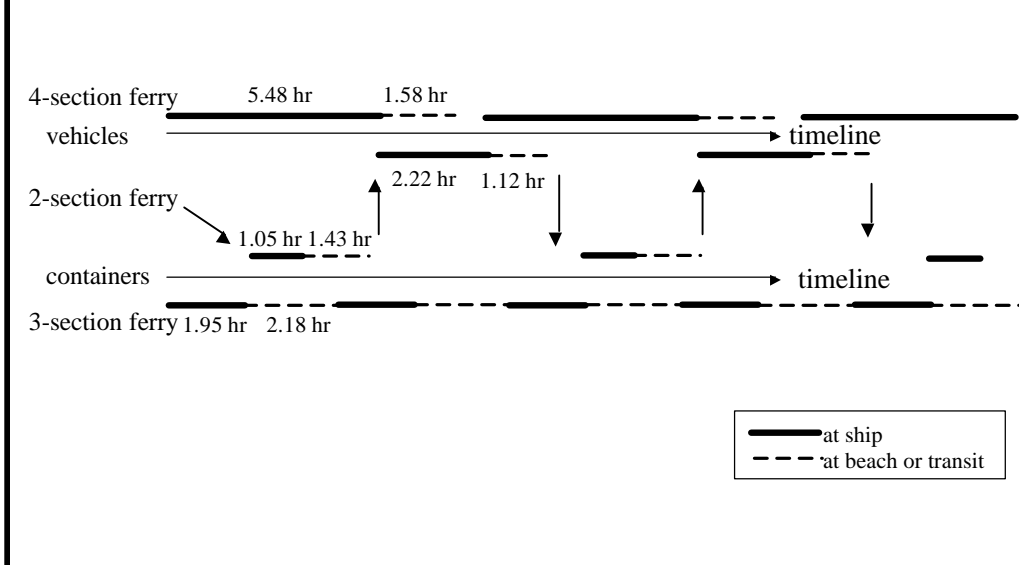
- Ferry composition: three 3-section ferries/MPF ship
- Ferry assignments: two for vehicles; one for containers and tanks
- Ship-to-shore range: 3 n.mi.
- Ferry speed: 10 knots
- Time to build ferries and warping tugs: .38 days
- Estimated time to offload ship/squadron: 8.3 days

This chart summarizes our base case. All three ferries consist of 3 sections, with 2 being dedicated to the more time consuming vehicle offload. The third ferry completes the offload of containers and tanks and then briefly helps with the vehicle offload.

The ship-to-shore range is 3 n.mi. The two-way transit time at 10 knots is 0.6 hour or 36 minutes. The 6-knot increase in speed over the 4 knots of current lighterage shortens the ferry's operating cycle by almost an hour.

The assembly of a warping tug takes 1.5 hours; each 3-section ferry requires 2.5 hours.

## 4, 3, and 2-section ferry ops (base tuned)



Recognizing that the two 3-section ferries offloading vehicles in the base case had several hours of idle time (see earlier slide depicting three 3-section ferry ops), we improved the efficiency of the ship offload by constructing three ferries with 4, 3, and 2 sections in place of the three 3-section ferries. We then dedicated the 4-section ferry to vehicles and the 3-section ferry to containers, and alternated the operations of the 2-section ferry between vehicle and container operations. The net effect was to maintain the near-continuous vehicle offload operations (20 out of each 24 hours), while supplementing the container offload operation.

The diagram (roughly to scale) in the slide depicts the overall operation. We refer to this strategy as optimizing the base case. The next slide describes and summarizes the performance of this optimized base case.

## **Base case (optimized)**

- Ferry composition: one 4-section, one 3-section, and a 2-section ferry/MPF ship
- Ferry assignments: 4-section for vehicles; 3-section for containers/tanks; 2-section for vehicles/containers
- Ship-to-shore range: 3 n.mi.
- Ferry speed: 10 knots
- Time to build ferries and warping tug: .38 days
- Estimated time to offload ship/squadron: 7.5 days

This slide summarizes the base case (optimized) excursion. The three ferries are assigned to cargo offload operations as indicated: the largest 4-section ferry is dedicated to vehicles, and the 3-section ferry is dedicated to containers. The 2-section ferry alternates its load between vehicles and containers. The offload of containers takes about 6 days, and the offload of vehicles can be done in roughly 8 days. Assuming that the 2- and 3-section ferries shift their operations to tanks and vehicles during the final stage of the offload, the overall ship offload can be accomplished in 7.5 days. These figures include the time needed to assemble warping tugs and ferries.

## **Base case and 6-n.mi. standoff**

- Ferry composition: three 3-section ferries/MPF ship
- Ferry assignments: two for vehicles; one for containers and tanks
- Ship-to-shore range: 6 n.mi.
- Ferry speed: 10 knots
- Time to build ferries and warping tug: .38 days
- Estimated time to offload ship/squadron: 8.7 days

Here we explore the implications of increasing the ship's standoff range from the beach to 6 n.mi. We use the base case ferry structure, assigning two 3-section ferries to vehicle offload, and one 3-section ferry to containers and tanks.

The increased transit time from 0.6 to 1.2 hours does not affect the offload time for vehicles (note earlier slide depicting base case ops), since there is always a ferry available for those operations. However, it does delay the offload of containers and tanks slightly. The net delay for that offload is less than a half day. The 10-knot ferry speed offered by the INLS makes it more flexible than current lighterage in handling greater ship-shore separations.

As with the base case, this excursion could be tuned or optimized to reduce the offload times by roughly one day.

## **Base case with loss of a power section**

- Ferry composition: one 4-section ferry and a 3-section ferry for each ship
- Ferry assignments: 4-section for vehicles; 3-section for containers and tanks
- Ship-to-shore range: 3 n.mi.
- Ferry speed: 10 knots
- Time to build ferries and warping tug: .38 days
- Estimated time to offload the ship: 9.3 days

This excursion looks at the impact on squadron ships of losing one of the three power sections available in the base case. Using the middle sections of the ferries with a casualty to construct 4-section ferries for vehicle offload, a two- ferry operation could carry out each MPF ship's offload with a relatively modest delay. The container/tank offload would proceed in the same manner as the base case. The vehicle offload would take slightly over 10 days. Considering the time to build ferries, and assuming a cooperative effort by the two ferries, a complete ship offload would take about 9.3 days. This is roughly an increase of one day over the base case.

Actually if only one ferry in the squadron lost a power section, ferries from other ships would be available to help that ship after 8.3 days (see base case). The offload time would then drop to about 9 days.

## **Twelve-ferry force for MPF squadron**

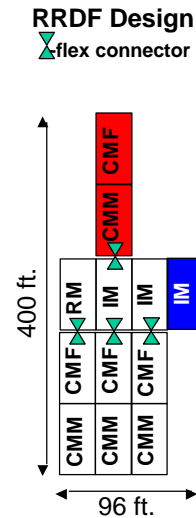
- Ferry composition: 2 ships with 4-, 3- and 2-section ferries; 3 ships with 4- and 3-section ferries
- Ferries from 2 ships with 3 ferries support offloads of 3 ships with 2 ferries after 7.5 days
- Ship-to-shore range: 3 n.mi
- Ferry speed: 10 knots
- Time to build ferries and warping tugs: 30 days
- Estimated times to offload the squadron:
  - 2 ships: 7.5 days
  - 3 ships: 9.1 days

At the request of the sponsor, this excursion considers a reduction in the number of ferries by three. The resulting ferry force has five 4-section ferries, five 3-section ferries two 2-section ferries.

The two ships with three ferries offload their cargo in 7.5 days (base optimized excursion). After that all available ferries work with the three remaining ships and complete the squadron offload in 9.1 days. Eliminating the two 2-section ferries (alternative 3, 10 ferries) is only 0.2 days longer. If cost or weight constrains INLS for MPF, the 10-ferry option is a better choice.

# RRDF Considerations

- The base design INLS RRDF:
  - has 12 sections (each 80'x24')
  - 11 of 12 sections can be used as ferry center sections
  - Weighs 1,000 LT
- Variations examined:
  - 9-section rectangular (colored modules deleted)
  - 10-section variant (red finger pier deleted)
- Ferry interoperability:
  - Intermediate module (IM) same as ferry's
  - CMM/CMF pair interoperable as ferry intermediate module, but twice as long



Building a squadron RRDF essentially decreases the offload time for vehicles on one ship. However, the lighterage lost to the remaining ships in the squadron results in a net increase for the time to offload.

The slide describes the base INLS RRDF design of twelve sections. Eleven of these sections (8 CMs and 3 IMs) can also be used to construct ferry center sections. The RRDF weighs about 100 LT more than the 11 ferry IMs that it replaces.

Variations to the RRDF design that also might work use 9 and 10 sections as illustrated in the figure.

Noteworthy is that the CMs must be paired in the construction of ferries. This results in a 4-section ferry. Intermediate modules can be used to build both 3- and 4-section ferries.

## **Stern RRDF for MPF squadron**

- RRDF kit (12 sections)
  - 1 ramp module (24 x 80 ft)
  - 3 intermediate module (24 x 80 ft)
  - 4 combination modules (M) (24 x 80 ft)
  - 4 combination modules (F) (24 x 80 ft)
- RRDF weight: 1,000 LT
- Operational pluses
  - Faster offload of vehicles from one ship
  - Compensation for loss of ship crane
- Operational negatives
  - Reduces ferries available weight/space for squadron offload
  - Serves only 1 ship at time
  - Involves some delay for assembly/movement between ships

The Fleet has a requirement for using an RRDF [4] to speed up the offload of vehicles in an MPF squadron. We assume that the offload time per vehicle for the ship with access to the RRDF could be reduced by 50 percent to 7 minutes. We also estimate it would take up to 0.8 day to build the ferries and construct an RRDF, and about 4 hours to move it between ships.

The advantage of an RRDF is that it could provide an initial surge in the offload of vehicles and possibly compensate for the failure of one or more cranes on a particular MPF ship.

Disadvantages of an RRDF are that it potentially adds a lot of weight to the MPF squadron unless the number of ferry sections are reduced. Also, it can serve at most two ships during an offload. We look at the use of an RRDF in our final excursion to the base case.

## **A squadron RRDF**

- Ferry composition:
  - Four ships with one 3-section ferries and two 2-section ferries
  - One ship with three 2-section ferries
- RRDF with 12 sections
- Ship-to-shore range: 3 n.mi.
- Ferry speed: 10 knots
- Time to build ferries, warping tug and RRDF: .8 days
- Estimated time to offload squadron: respective offload times of successive ships are 7.9, 8.6, 9.0, 9.3 and 10.2 days.

We assume that two 3-section ferries continually support the RRDF offload of vehicles on the two ships completing their offloads first. The remaining ferries assist the squadron offload of vehicles, containers and tanks. The overall reduction in the number of ferries from the base case ensures that the weight of the RRDF does not reduce MPF cargo.

The ship that benefits initially from the RRDF offloads its vehicles and tanks in about 5 days. Offload of a second's ships vehicles occurs by 8.6 days, most of the offload being supported by the RRDF.

Container offloads (not affected by an RRDF) by either a 3-section or two 2-section ferry are accomplished in about 7.5 days. The respective offloads times of the five ships range from 7.9 days to over 10 days, averaging 9.1 days.

This confirms earlier analysis that substituting RRDF components for ferry components in a lighter limited environment lowers the time to offload vehicles from a single ship, while increasing the total squadron offload time.

## Case summary for nominal MPF ship

case	INLS weight (LT)	# sections per ferry	total sections per squadron	offload days
Base (15 ferries)	4,922	10	50	8.3
base optimum	4,922	10	50	7.5
6 n.mi. rng	4,922	10	50	8.7
10 ferries	3,906	8	40	9.3
12 ferries	4,313	10 or 8	44	7.5 (2 ships) 9.1 (3 ships)
Sqd with RRDF	5,022	10 or 11	51	10.2

This slide summarizes the results for a nominal MPF ship in the base case and the four analysis excursions.

Assets for a nominal MPF ship, in terms of INLS weight, are listed in the second column. The third column lists the total number of INLS sections on each ship. The fourth column shows the total number of INLS sections in the squadron. The final column shows the nominal ship's offload time.

## References

- [1] Robert M. Souders. *JMLS Design Changes to Enhance Utility for Navy Maritime Prepositioning Force*, Jul 2000 (CNA Annotated Briefing D0000773.A2)
- [2] Robert M. Souders and William Asrat. *Joint Modular Lighter System (JMLS) Throughput Times*, Aug 2000 (CNA Annotated Briefing D0000754.A2)
- [3] Robert M. Souders. *Joint Modular Lighterage System (JMLS) Configuration and Throughput Analyses*, Dec 2000 (CNA Research Memorandum D0002811.A2)
- [4] *Sea State 3 Lighter System Quarterly Sponsors Program Review*, by Daniel McCluskey, Deputy Program Manager, 24 Sep 2001

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